FAA-E-2467
December 23, 1970

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION SPECIFICATION

AIRPORT SURVEILLANCE RADAR SOLID STATE COMMON EQUIPMENT FOR ARTS-III INTERFACE

1. SCOPE

1.1 Scope.- The equipment specified, herein, is the portion of the common equipment of an Airport Surveillance Radar (ASR) display system used to interface with the Automated Radar Terminal Service (ARTS-III) Displays. The equipment shall be solid-state in design and provide line compensation, range mark generation, and control switching for the ARTS-III displays.

2. APPLICABLE SPECIFICATIONS

2.1 FAA documents.- The following FAA specifications and standards, of the issues specified in the invitations for bids or request for proposals, form a part of this specification and are applicable in their entirety unless otherwise specified, herein.

2.1.1 FAA specifications.-

FAA-G-2100/1	Electronic Equipment, General Requirements; Part 1, General Requirements for all Equipments
FAA-G-2100/3	Part 3. Requirements for Equipment Employing Semiconductor Devices

FAA-G-2100/4	Part 4. Requirements for Equipment Employing Printed Wiring Techniques
FAA-G-2100/5	Part 5. Requirements for Equipments Employing Microelectronic Devices
FAA-D-638	Instruction Books, Electronic Equipment
FAA-STD-012	Paint Systems for Equipment
FAA-STD-013	Quality Control Program Requirements
FAA-E-163b	Rack, Cabinet and Open Frame Types
FAA-TS/S-120/801	FAA System Technical Description and Specification for a Modularly Expandable TRACON "C" Beacon Tracking Level System

(Copies of these documents, and of the applicable FAA specifications and drawings, may be obtained from Federal Aviation Administration, Washington, D. C. 20590, Attention: Contracting Officer. Requests should fully identify material desired, i.e., specification numbers, dates, amendment numbers, complete drawing numbers; also, requests should state the contract involved or other use to be made of the requested material.)

2.2 Military publications.- The following publications, of the issues in effect on the date of the invitation for bids or request for proposals, form a part of this specification and are applicable to the extent specified, herein.

2.2.1 Military standards.-

MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-756A	Reliability Prediction
MIL-STD-781B	Test Levels and Accept/Reject Criteria for Reliability of Non-Expendable Electronic Equipment
MIL-STD-17555	Electronic and Electrical Equipment and Associated Repair Parts, Preparation for Delivery Of
MIL-STD-470	Maintainability Program Requirements for Systems and Equipments
MIL-HDBK/C-217A	Reliability, Stress and Failure Rate Data for Electronic Equipment

(Single copies of Military specifications and standards may be requested by mail or telephone from U.S. Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120. For telephone requests, call (215) 697-3321, 8:00 a.m. to 4:30 p.m., Monday through Friday.)

2.3 Instruction Books.- The following documents have been referenced, herein, and will be available for use in the FAA Headquarters building:

Airport Surveillance Radar Display System (ASRDS) Type FA-7300
Airport Surveillance Radar Display System (ASRDS) Type FA-7700
Airport Surveillance Radar Display System (ASRDS) Type FA-4800
Airport Surveillance Radar Display System (ASRDS-3) Type FA-8150

3. REQUIREMENTS

3.1 Definitions

3.1.1 Service Conditions.- The service conditions shall be as specified in FAA-G-2100/1, paragraph 1-3.2.23. Ambient conditions shall be those of Environment I (1-3.2.23, FAA-G-2100/1).

3.1.2 Power source.- The common equipment shall operate from a single-phase AC line power source. The design-center value (1-3.2.21, FAA-G-2100/1 shall be 120V, 60Hz).

3.1.3 Reliability definitions

3.1.3.1 Meantime between failure (MTBF).- Meantime between failure, expressed in hours, is defined as the reciprocal of unit failure rate (λ). (MTBF = $1/\lambda$).

3.1.3.2 Unit failure rate (λ).- Unit failure rate is defined as the sum of the individual part density failure rates within a unit. The individual part density failure rate is the number of parts times the statistical failure rate for that part type.

3.1.3.3 Meantime to repair (MTTR).- Meantime to repair is defined as the meantime to effect repair of the unit and to put the unit in an "up" condition, or if spare modules are provided, the time required to replace a failed module.

3.1.3.4 Failure.- As used herein, failure is defined as any loss of system operational capability; for example, performance outside of specified tolerances, which cannot be corrected by maintenance control adjustment.

3.2 Equipment to be furnished by the contractor.- Each common equipment rack shall be complete in accordance with all specification requirements. Any item or part necessary for proper operation of the equipment in accordance with the requirements of this specification shall be incorporated, even though that item or part may not be specifically provided for or described, herein. All features required to meet performance requirements, such as shock mounting of particular components or assemblies, heat circulation by

means of blowers, controls, indicator lamps, overload and overheat protection devices, meters, test points, etc., shall be incorporated even though the features may not be specifically provided for or described, herein. All necessary facilities, parts, and hardware, including receptacles, connectors, intra-cabinet cabling (wiring), adapters, and outlets shall be incorporated to enable the components of the system to be properly assembled and interconnected as required.

3.2.1 Deliverable items

(a)	Line Compensator/Amplifier (3.4.2)	2 each
(b)	Range Mark Generator (3.4.3)	2 each
(c)	Local Control Panel (3.4.6, 3.4.7.1)	2 each
(d)	Remote Control Panel (3.4.6, 3.4.7.2)	1 each
(e)	Relay Panel (3.4.8)	2 each
(f)	Power Supplies (3.5)	2 each
(g)	Instruction Books (3.11, 3.12)	
(h)	Special Maintenance Tools (3.10)	
(i)	Blank Panels (3.4.1)	
(j)	Reliability Calculations (3.7)	

3.3 Basic design requirements.- The prime objective of the design shall be the achievement of maximum operational reliability and ease of servicing.

The equipment shall be of solid-state design, utilizing modular plug-in cards wherever possible, in accordance with FAA-G-2100/4. The equipment shall be designed so that all alignment adjustments, maintenance, and replacement of parts can be performed by only one technician. The equipment described, herein, shall have no rotating machinery, with the exception of any required blowers.

The equipment shall be so designed as to be contained in one rack as described in (3.4.1).

3.4 Performance requirements.- The common equipment specified, herein, shall be dual-channeled with each channel having independent operation. The common equipment shall accept normal radar video, MTI radar video, and radar pretrigger and supply outputs, as described in paragraph 3.4.8.1 to PPI displays. This equipment shall include facilities for line compensation (equalization of primary radar video), separation of the composite normal video from radar pretrigger, range mark generation, equipment control circuitry, and relay switching circuitry.

3.4.1 Common equipment cabinet.- The common equipment cabinet shall be in accordance with FAA-E-163b and include the following solid-state equipment units:

(a)	Line Compensator/Amplifier (3.4.2)	2 each
(b)	Range Mark Generator (3.4.3)	2 each
(c)	Local Control Panel (3.4.6, 3.4.7.1)	2 each
(d)	Remote Control Panel (3.4.6, 3.4.7.2)	1 each

(e)	Relay Panel (3.4.8)	2 each
(f)	Power Supplies (3.5)	2 each
(g)	Digital Sweep Generator (GFE) (3.4.1)	2 each

At least 28 inches of unused panel space shall be provided for GFE (3.4.1 g). Any unused panel space in the rack shall be supplied with blank panels.

The cabinet shall be 27 inches in width, 26 inches in depth, and shall not exceed 76 inches in height. The cabinet shall be provided with full length, latching access doors on both front and rear. Ventilation exhaust shall be from the top of the cabinet or from near the top of the rear access door. If a vent is selected, it shall be designed so that small objects, such as screws or nuts falling from above, will not enter the cabinet. Cable access to the cabinet shall be at the top, and shall be adequate to easily accommodate all of the cables required to run an independent set of cables to the operating positions and an independent set to the maintenance position. The common equipment cabinet shall incorporate all wiring and cabling necessary to interconnect all required equipment units mounted in it.

3.4.2 Line compensator/amplifier.- Line compensator/amplifiers shall be provided and installed in the common equipment cabinet (3.4.1). These modular line amplifiers shall separate the normal video and the radar pretrigger, and provide two isolated outputs for each. Two isolated outputs shall also be provided for the MTI video.

The fidelity and recovery characteristics of the video and trigger compensating/amplifying equipment, when operating through 12,000 feet of RG-13/U or equal cable, shall be such as to faithfully reproduce the video and trigger output of the radar transmitter-receiver equipment. The line compensator/amplifier shall compensate for line loss and phase shift versus frequency for video and triggers remoted over the coaxial lines. Compensation for line lengths from 0 to 12,000 feet shall be provided by solder-in straps. The line compensator/amplifier shall attentuate, by a minimum of 20 db, any AC power frequency potential appearing on the input coaxial line as a result of differences in ground potential between the transmitter and indicate sites. All outputs shall be adjustable between the limits specified in paragraph 3.4.2.2 for any length of remoting up to 12,000 feet. The line compensator shall be capable of driving 100 ohm terminated cable up to 300 feet in length.

3.4.2.1 Input.- The line compensator/amplifier shall be capable of operating with the following video inputs from two BNC coaxial cables. The normal video and pretrigger will be combined on a single coaxial line and the MTI video will be on the other coaxial line. Two BNC connectors shall be provided for each video input so that each input cable may be either terminated into a 75 ohm resistive load or extended to another line compensator/amplifier. The characteristics of the input videos are as follows:

(a)	Video (Normal, MTI, and Pretrigger)	Positive
(b)	Video amplitude	.5 volts min; 3 volts nominal; 6 volts max.

(c)	Pretrigger amplitude	3 volts min.
(d)	Pretrigger position	0 to 125 microseconds prior to zero range
(e)	Pretrigger PRF	800 to 1200 pulses/sec
(f)	Trigger pulse width	1 microsecond ± 10%
(g)	Rise time	.1 microseconds 10% - 90%

3.4.2.1.1 Trigger staggering.- Either of two different types of trigger timing will be encountered as specified below:

(a) Triggers will occur at regular time intervals within the approximate range of 667 microseconds to 1429 microseconds, as determined by operation of the associated radar on a single PRF within the range of 700 to 1500 pulses per second.

(b) Triggers will occur at irregular time intervals, each interval within the approximate range of 833 to 1429 microseconds, as determined by random sequential, repetitive operation of the associated radar on up to six discrete PRF's within the range of 700 to 1200 pulses per second.

Performance of the common equipment system shall be in accordance with all requirements specified herein for both (a) and (b) above. Sweep countdown shall not occur for triggers within the range of 700 to 1500 pulses per second; rather, limiting of the maximum displayed range to less than 60 nautical miles shall occur at trigger PRF's in excess of 1200 pulses per second.

3.4.2.2 Output.- The output characteristics of the line compensator/amplifier shall be as follows:

(a)	Video (Normal, MTI, and Pretrigger)	Positive
(b)	Video amplitude	2.0 to 4.0 volts
(c)	Pretrigger amplitude	30 to 90 volts
(d)	Pretrigger position	50 to 125 microseconds
(e)	PRF	800 to 1200 pulses/sec
(f)	Impedance design center	100 ohms

3.4.2.3 Video response.- The line compensator/amplifier shall exhibit overall video bandpasses as listed below. Overshoot and undershoot for all video channels shall not exceed 10% of the nominal peak amplitude of the input pulse. Operation in accordance with all specification requirements shall occur for video input levels between .5 and 6 volts peak.

(a) Normal video bandpass - At any frequency between 1,000 Hz and 2.5 MHz, the video response shall not deviate by more than 1 db

from the response at 100 KHz. At any frequency between 60 Hz and 3.0 MHz, the video response shall not deviate by more than 3 db from the response at 100 KHz.

(b) Normal video droop - Not to exceed 20% with 4 volt, 200 microsecond input pulse.

(c) MTI video bandpass - At any frequency between 1,000 Hz and 3.0 MHz, the video response shall not deviate by more than 1 db from the response at 100 KHz. At any frequency between 60 Hz and 3.5 MHz, the video response shall not deviate by more than 3 db from the response at 100 KHz.

3.4.3 Range mark generator.- The range mark generators shall be provided and installed in the Common Equipment Cabinet (3.4.1). The range mark generator shall be capable of producing the range marks as specified below:

(a) 2-mile range rings with every 5th ring intensified.
(b) 5-mile range rings with every 5th ring intensified.
(c) 10-mile range rings with every 5th ring intensified.

All range marks shall be derived directly, or by counting down from a crystal controlled frequency-stable oscillator, so that all range marks are traceable to a single frequency source. The combination of accuracy and stability of the basic range mark timing oscillator shall be such as to produce range marks accurate to within $\pm$ 1/64 of a mile over the range of the service conditions. Under normal test conditions, the long term drift of the one mile marks shall not exceed $\pm$ 1/64 of a mile over a week's period of operation. The frequency of the basic range mark timing oscillator shall be adjustable over a range sufficient to compensate for tolerances or replacement components and for long-term draft. The time intervals between range marks shall be equal and constant, within the limits specified above, and no spurious range marks shall be displayed. A maintenance control, separate from the sweep start control, shall be incorporated to permit adjustment of the zero range mark to be coincident with ASR zero range and to precede or follow ASR zero range by at least ten (10) microseconds with no noticeable jitter. The range of this control shall be adequate to accommodate synchronizing pretriggers timed from 0 to at least 120 microseconds ahead of the main radar pulse (zero range). Range of pretrigger amplitude will be between 10 and 75 volts. Range mark duration shall be .1 $\pm$ .05 microseconds. The range mark generator shall generate its own range gate.

A maintenance control shall be provided to adjust the upper limit of the front panel range mark intensity control. Independent intensification of each fifth range mark shall be provided. The range mark generator shall be capable of driving a 100 ohm terminated cable up to 300 feet in length.

Two isolated outputs shall also be provided for the two (2), five (5), and ten (10) mile range marks.

3.4.4 Redundancy.- Since the line compensator/amplifier and the range mark generator are common to all PPI display consoles, two identical independent units of each shall be provided for dual channel operation. The outputs of the line compensator/amplifiers and the range mark generators shall be routed to a relay panel (3.4.8) where either the Channel A or Channel B may be selected to drive the PPI display consoles. Both channels shall be continuously in the operating condition. To avoid the necessity of switching the inputs to the line compensator/amplifier and range mark generator, they shall be connected in parallel and that removal from the cabinet, deenergizing, or failure of the unselected unit shall not affect the selected unit. In addition, two identical Digital Sweep Generator units are provided as GFE, and shall be incorporated into the common equipment cabinet in the same configuration as specified above.

3.4.5 Channel A and Channel B equipment.- One set of the dual channel common equipment shall be designated as Channel A and the other as Channel B. The units of the CH A and CH B equipments shall be completely interchangeable, and it shall be possible for one technician to interchange units.

3.4.6 Control panel operation.- Complete transfer of operation from one common equipment to the other shall be controllable by the operation of two sets of CH A/CH B selector switches. One of these sets of selector switches shall be located on a CH A/CH B Operations room control panel (3.4.7.2), and the other shall be located on an Equipment room control panel (3.4.7.1) in the Common Equipment Cabinet. The switches having control of all CH A/CH B functions shall be determined by the position of the equipment room local/remote switch, also to be located on the Equipment room control panel.

The local/remote switch shall simultaneously change the point of control of all the functions to either the equipment room (local position) or operations room (remote position). An equipment room maintenance enabling circuit shall be incorporated, which shall be under the full control of the operations room. An equipment room maintenance enabling momentary contact switch shall be mounted on the CH A/CH B control panel in the operations room. With this switch in the released position, the equipment room master local/remote switch shall be mechanically locked out. Energizing of this switch shall enable the local/remote switch in the equipment room to move from the remote to the local position. The local/remote switch shall be capable of switching from the local position to the remote position without use of the enabling switch.

The operation of the equipment room local/remote switch shall never cause transfer of operation from the selected equipment to the unselected equipment.

The CH A/CH B selector switches shall transfer control from one set of equipment to the other in such a manner that satisfactory operation can continue after changeover without the necessity of making adjustments to the equipment.

In case of power failure, restoration of power shall place the equipment in the same status and on the same equipment existing before power failure.

The equipment shall indicate "No Control" when the equipment room local/remote switch is in the local position and available when the equipment room local/remote switch is in the remote position.

All control panel switches shall be momentary contact switches.

A spare local control panel shall be provided installed in the cabinet side by side, above or below the corresponding operating unit, and change-over from one to the other shall be made either by operating transfer switches or by transferring cables having rapid-disconnect connectors from one unit to another without removing either unit from the cabinet.

3.4.7 Control functions.- The following are lists of the required control functions:

3.4.7.1 Local control panel.- The following functions shall be located in the equipment room and shall be located on a panel installed in the common equipment cabinet:

(a) Main power ON/OFF
(b) Channel A power ON/OFF
(c) Channel B power ON/OFF
(d) Channel A SELECT
(e) Channel B SELECT
(f) Maintenance local/remote switch (3.4.6)
(g) Maintenance Channel A - Channel B select switch (3.4.9)

3.4.7.1.1 Local control panel lights.- The following indicator lights shall also be provided:

(a) Main power ON/OFF lamp
(b) Channel A power ON/OFF
(c) Channel B power ON/OFF
(d) Channel A available lamp
(e) Channel B available lamp
(f) No control lamp
(g) Channel A select lamp
(h) Channel B select lamp

3.4.7.2 Remote control panel.- The following functions will be remoted to the operations room where a panel shall be provided:

(a) Channel A equipment select
(b) Channel B equipment select
(c) Maintenance enable switch (3.4.6)

The remote control shall be designed such that it can be either installed in place of the FA-4993 panel located on the FA-4970 radar and equipment control panel assembly or designed as a separate control box capable of being wallmounted. The panel shall be adaptable to both conditions.

3.4.7.2.1 Remote control panel light.- The following indicator lights shall also be provided:

(a) Channel A select lamp
(b) Channel B select lamp
(c) Channel A available lamp
(d) Channel B available lamp
(e) No control lamp
(f) Panel illumination lamps

3.4.8 Relay panel.- A relay or switching panel shall be provided capable of switching the outputs of the Channel A and Channel B common equipment, by means of the control panels as described in paragraphs 3.4.6 and 3.4.7. It shall be installed in the common equipment cabinet. A spare relay panel shall be provided installed in the cabinet side by side, above or below the corresponding operating unit and changeover from one to the other shall be made either by operating transfer switches or by transferring cables having rapid-disconnect connectors from one unit to another without removing either unit from the cabinet.

The relay panel is to be wired with at least 20% spare control circuits (minimum of one) of each type used to facilitate the addition of similar control circuits for future use. The dummy control circuits are to be completely wired through the switches, relays, and connectors and terminated on cabinet terminal boards.

3.4.8.1 Relay panel outputs.- The following outputs as a minimum shall be available at the output of the relay panel:

(a)	Normal video	(BNC coax)	
(b)	MTI video	(BNC coax)	
(c)	Pretrigger	(BNC coax)	
(d)	Spare video	(BNC coax)	
(e)	Spare video	(BNC coax)	
(f)	2-mile marks	(BNC coax)	
(g)	5-mile marks	(BNC coax)	
(h)	10-mile marks	(BNC coax)	
(i)	Alphanumeric trigger (1-6)	(BNC coax)	
(j)	Alphanumeric trigger (7-10)	(BNC coax)	
(k)	End of live time	(BNC coax)	
(l)	Dead time trigger	(BNC coax)	
(m)	End dead time	(Hi and Lo)	(twisted pair SHD)*
(n)	Pretrigger	(Hi and Lo)	(twisted pair SHD)*

(o)	Azimuth strobe	(Hi and Lo)	(twisted pair SHD)*
(p)	Sine data	(Hi and Lo)	(twisted pair SHD)*
(q)	Cosine data	(Hi and Lo)	(twisted pair SHD)*

*Wire - Teflon insulated #20 twisted shielded pair.

3.4.9 Maintenance Channel A - Channel B select switch.- It shall be possible, by means of a switch located on the equipment room control panel, to select either the selected or unselected channel (Channel A or Channel B) to feed the maintenance PPI display with the information in paragraph 3.4.8.1.

3.4.10 Impedance.- The outputs (3.4.8.1) from the common equipment shall be isolated such that information running to the operations PPI displays and the maintenance PPI shall not be degraded by a short or an open except for the output with the short or open.

3.4.11 Equipment supplied as GFE.- The equipment supplied as Government-furnished equipment is a Digital Sweep Generator. Two Digital Sweep Generators are supplied to incorporate dual channel operation. Each unit includes self-contained power supplies. The Digital Sweep Generator is furnished with all interconnecting plugs. Each unit requires 14 inches (height) of panel space. The depth from the mounting panel to the rear is 5 1/4 inches and 6 inches from the mounting panel to the front handles.

The Digital Sweep Generator, as such, does not contain two isolated outputs as required of the equipments in this specification. Therefore, the contractor shall provide necessary provisions for the following combination of equipment conditions without degradation of the Digital Sweep Generator operational performance:

(a)	CH A operational	CH A maintenance
(b)	CH A operational	CH B maintenance
(c)	CH B operational	CH A maintenance
(d)	CH B operational	CH B maintenance

3.4.11.1 Input.- The following is a list of inputs required for the Digital Sweep Generator:

(a)	Azimuth Reference Pulse	(GFE BNC coax)
(b)	Azimuth Clock Pulse	(GFE BNC coax)
(c)	Pretrigger (from line compensator)	(BNC coax)
*(d)	A. C. Power Requirements	125 watts (120 VAC) per converter

*Power shall be obtained from terminal block in Common Equipment Rack and shall be controllable from the power switches in the local control panel.

3.4.11.2 Output.- The outputs from the Digital Sweep Generator are either BNC coax cable or twisted pair cable with all twisted pair cable combined into one cannon plug type output. These cables, whether BNC coax or twisted pair,

shall become part of the functional inputs to the relay panel (3.4.5.2). The outputs from the Digital Sweep Generator are as follows, and are included in the relay panel as specified in (3.4.5.2.1) as outputs:

(a)	Sine data	(twisted pair SHD)
(b)	Cosine data	(twisted pair SHD)
(c)	Azimuth strobe	(twisted pair SHD)
(d)	Pretrigger	(twisted pair SHD)
(e)	End dead time	(twisted pair SHD)
(f)	Dead time trigger	(BNC coax)
(g)	End live time	(BNC coax)
(h)	Alphanumeric trig 1-6	(BNC coax)
(i)	Alphanumeric trig 7-10	(BNC coax)
(j)	Spare	(BNC coax)
(k)	Ground	(single wire)

3.5 Common equipment power supplies.- Two identical, independent power supplies shall be furnished to drive all equipments mounted in the common equipment cabinet. Each power supply shall be of sufficient capacity to drive up to 150 percent of the common equipment requirements. Both power supplies shall operate continuously and their outputs shall be connected through diodes or other isolating devices to common busses. A short in any of the outputs of either supply ahead of the isolation device shall not affect the other supply. Provisions shall be incorporated to permit removal of either power supply from the cabinet without affecting system operation, or to work on either power supply in the cabinet without affecting system operation or hazards to maintenance personnel. Positive indication of power supply failure shall be given by pilot lights on the power supply.

Operating and spare power supplies for the control circuits shall be provided in the common equipment rack if a separate power supply is required.

All power supplies shall be self-protecting such that without the use of fuses, circuit breakers or other protective devices, a continuous short across the power supply output will not damage circuit components and the output voltage will return to normal upon removal of the short circuit.

3.5.1 Regulation.- All power supplies, except those specifically exempted, shall be electronically regulated to maintain output voltage to within 1% of the nominal value as the load is varied from 10% less than to 20% more than the normal load, and as the line voltage is varied between the service condition limits. The output voltage of regulated supplies shall be continuously variable over a minimum range of $\pm$ 10% of the nominal value, and the regulation and ripple specifications shall be met for any value of the output voltage within its adjustment range. Power supply output voltage shall not vary by more than $\pm$ 1% from the initial setting during operation over the service conditions. The use of selenium

rectifiers is prohibited. Each regulated power supply shall employ its own separate voltage reference device, and shall not rely upon another power supply for a voltage reference. Whenever practicable, individual chassis or modules shall be employed for each power supply. If a low voltage control circuit power supply is employed, it is not required to be electronically regulated.

3.5.2 Ripple voltages.- Ripple voltages, defined as the peak-to-peak value of a simple or complex waveform consisting of power line frequency components and harmonics thereof, and synchronous or repetitive non-synchronous transients, shall not exceed 0.1 volt peak-to-peak for all electronically-regulated power supplies. The control circuit low voltage supply (if used) is exempt from this requirement. The ripple voltage of all power supplies shall be such that all specification requirements are fulfilled and further reduction of the ripple voltage would not result in any significant improvement in the stability of operation, circuit control adjustments, or equipment operation.

3.5.3 Metering.- Meters and associated switches for use in measuring all power supply output voltages and currents shall be provided, except where the contractor and the Government mutually agree that voltage test points would be sufficient or that no metering is required (where indications are not significant and where circuitry is unduly complicated). They shall be located preferably on the front panels of the cabinet containing the circuits to be metered, but may be located elsewhere, provided they are visible with the cabinet doors opened. When a meter is utilized to measure only one parameter, the meter shall read directly. Each meter shall be provided with a replacable card insert mounted near the meter to designate the proper reading of each associated switch position. If a meter cannot be used for multiple functions without external shunts or multipliers, such shunts or multipliers shall conform to the requirements of paragraph 1-3.16. of Specification FAA-G-2100/1. Operation of meter selector switches shall not interfere with proper system performance, such as might be caused by meter insertion to read current, or transients caused by meter selector switching.

3.5.4 Power supply indicators.- Each circuit protected by a fuse or circuit breaker shall have an indicator lamp which shall be illuminated when the fuse (or circuit breaker) is open. Neon indicator lamps shall be used whenever this is practicable. All indicator lamps shall be uniformly located with respect to their associated fuses or circuit breakers, or they may be an integral part of the fuse holder assembly.

3.5.5 Line voltage regulators.- Line voltage regulators shall not be used as a means of meeting the system performance requirements under service conditions.

3.5.6 Primary power.- All performance requirements for the system shall be met without readjustment when primary power supply voltages and fre-

quencies vary, rapidly or slowly, between the limits specified in paragraph 3.1.1. There shall be no discernible variation in system performance, including display presentation, during primary power line voltage changes.

3.5.7 Convenience outlets.- Each common equipment rack shall include a convenience outlet on the front and back of the equipment. The convenience outlet shall be provided in accordance with FAA-G-2100/1 paragraph 1-3.6.4.

3.5.8 Overvoltage protection circuitry.- Overvoltage protection circuitry shall be provided to automatically remove any excessive high voltage from circuits which would be damaged by an over-voltage condition.

3.6 Maintainability.- A formal demonstration of maintainability is not required; however, this does not relieve the contractor from designing the equipment to meet the specified MTTR, MTBPM, and MPMT. The requirements of MIL-STD-470 shall be used as guidelines in attaining this end.

3.7 Reliability.- The contractor shall submit predicted MTBF/MTTR reliability calculations for the equipment to be delivered, using the method contained in MIL-STD-256A and MIL-HDBK-217A. The Common Equipment Assembly shall exhibit a minimum MTBF of 10,000 hours and a maximum MTTR of 1 hour per channel.

3.8 Reliability demonstration option.- A reliability demonstration shall be conducted in accordance with test Plan V, Test Level A-1 (MIL-STD-781B) on the equipments specified, herein. The minimum number of test units to be used for the reliability demonstration shall be as specified in the contract.

3.9 General Requirements

3.9.1 Construction

3.9.1.1 Mechanical Construction.- The equipment cabinet shall be in accordance with FAA-E-163b. The equipment cabinet shall be fabricated from steel or aluminum material. The structural strength and rigidity of the cabinet shall be independent of any strength and rigidity furnished by access doors. The design shall provide maximum accessibility for maintenance and repair of units, components, and circuits, as well as neat and pleasing appearance. Each unit shall be removable from the front of the cabinet without requiring the partial or complete removal of any adjacent unit. The cabinet shall be of high quality, sturdy construction, accurately and carefully fabricated.

All cabinet assemblies shall be designed so that it will not be necessary to bolt or fasten down the equipment; however, facilities to bolt or fasten down the cabinet shall be provided. With all panels and doors

extended to their limits, the cabinet shall remain in a stable, upright position without being bolted down. All access doors shall be mounted by slip-pin hinges so that doors may be removed easily from the cabinet. These hinges shall be adjustable and shall be fastened by means of machine screws and nuts rather than by welding. Panels and chassis shall be adequately braced and of sufficiently small size and weight to permit removal and replacement of units by one technician for maintenance or repair of units on bench or for interchanging of units without any danger of permanent sets or deformation due to the normal handling of the units.

3.9.1.2 Wire and cable protection.- All individual wires and cables subject to chafing or abrasion shall be suitably protected; this protection shall be independent of the individual wire or cable insulation or jacket. This requirement is in addition to the requirements of 1-3.10.7, FAA-G-2100/1, and does not relieve the contractor from compliance with 1-3.10.7.

3.9.1.3 Ventilation and cooling.- If the equipment cabinet requires forced ventilation it shall contain its own blower system and shall require no external air ducts, in accordance with 1-3.9, FAA-G-2100/1. The equipment design shall be such that with all access doors of any cabinet open for up to eight (8) hours for servicing, the equipment shall not overheat or develop hot spots exceeding the allowable temperature rise. Under normal test conditions, all performance requirements shall be met after the access doors have been open for up to four (4) hours. "Air filters shall be removable from the exterior of the equipment without the necessity of opening access doors; this requirement is in addition to the requirements of 1-3.9.4 of FAA-G-2100/1. The Common Equipment shall meet Condition B of 1-3.5.11 of FAA-G-2100/1.

3.9.1.4 Cabinet illumination.- Shielded lights for general illumination of the cabinet interiors shall be provided behind the front and rear access doors.

3.9.2 Packaging.- The basic packaging concept of the equipment shall be modular plug-in cards or small plug-in assemblies to the greatest extent consistent with good engineering practices. This does not relieve any other requirements, e.g., RFI integrity, operation under environmental conditions, reliability, system performance, system capability, functional capability, etc. It is realized that portions of the system are not amenable to this type of modular construction. Cabinet layout and modular configuration shall be subject to Government approval.

3.9.2.1 Modular concept.- The configuration of the modular assemblies shall be based on one of the following options:

(a) Standard rack mounting assemblies mounted on chassis/slideout drawers. Drawer slides shall be heavy-duty locking type for

securing the panel assembly in either the normal or extended position. In the extended position, slides shall permit pivoting the assembly through ± 90 degrees from its normal operating position. Printed circuit (PC) plug-in modules shall be mounted vertically in PC card racks.

(b) Standard rack mounting assemblies with shelf mounted modules that plug into a front panel/chassis assembly. Spot welding may be used in lieu of screws and nuts in the sheet metal manufacture and assembly of module shelf and plug-in modules where it is not detrimental to the operation or maintenance of the equipment.

3.9.2.2 Plug-in modules.- Printed circuit card modules shall be mounted side-by-side, bookcase style, in an assembly, and shall be equipped with chassis guide strips, or rails, or both and mating connectors, etc., as are necessary to ensure positive circuit connections of the module with its mating assembly receptacle. Quick acting fasteners shall securely lock front panel type of plug-in modules in place in their operating position. Each printed-circuit board and card shall include identification markings which identify the basic circuit function and type number of the assembly of which it is a part.

3.9.2.3 Printed-circuit board supports.- All boards shall be supported within one inch of the edge on at least two edges not including the edge with the connector. Support shall be provided to prevent fracture or loosening of the foil due to flexing the board.

3.9.2.4 Printed-circuit board connectors.- The printed-circuit board connector receptacles shall contain a polarizing key and the key location or form shall be different for each different type of printed-circuit board. All boards of the same type shall have the same polarizing key location or form to insure insertion of the proper type board. Mating connectors shall be designed for repeated use with the module to ensure long-term reliable performance and with suitable mountings to permit positive connection-meshing without jamming or otherwise damaging the connector elements.

3.9.2.5 Printed-circuit board removal.- All printed-circuit boards shall include a convenient means for aiding maintenance personnel in grasping the board for removal from its mounting. This may consist of a special handle, cutout reinforced for finger holds or similar means. A special removal tool shall not be required. The method used by the contractor shall permit easy removal of the board without damage or undue strain of the board or any component mounted thereon.

3.9.2.6 Reserve card capacity.- Reserve circuit card capacity shall be provided to accommodate 20% more cards (minimum of one) in each bin than the equipment requires.

3.9.2.7 Printed-circuit board extender.- With each equipment, there shall be supplied a printed-circuit board "extender." An extender consists of a printed-circuit board (not keyed in order to permit insertion into any connector) provided with printed circuitry to extend all plug input points across the board to a receptacle on the opposite end, into which receptacle a removed printed-circuit board can be plugged. The extender board thus provides an accessible active operating position for any printed-circuit board normally inaccessible for ready maintenance and test while within the card cage. The extender shall be furnished installed in a spare blank printed-circuit board receptacle position provided for that purpose. The card extender and printed circuit boards shall be keyed to prevent reversal of a PCB when using the extender board.

3.9.2.8 Front panel connectors and cables.- Front panel connectors and cables shall be limited to those required for testing or in cases where it is not feasible to route signals through rear connectors. Such cases shall require specific Government approval. All other cables shall be to the rear.

3.9.2.9 Test points.- Test points shall be provided for measurement and observation of all voltages and waveforms needed for checking performance and for maintenance of individual units. Except where the functioning of circuits would be adversely affected by long leads, test points shall be accessible on the front panels or immediately behind the access doors of all units. Test points necessary for frequent alignment and adjustment purposes shall be provided at the front plug-in cards and modules and shall be accessible without a card extender. Test points for waveforms shall be provided with jacks suitable for use with oscilloscope test leads. Tip jacks shall be provided for the measurement of voltages, with red tip jacks for positive potentials, violet tip jacks for negative potentials, and black tip jacks for ground. All test points shall be identified with a TP number; and a voltage value, signal waveform, or descriptive title (if voltage value or waveform would not be particularly significant) shall be indicated adjacent thereto, as well as on each schematic diagram. Only descriptive titles or voltage values shall be shown for test points on exterior front panels. Suitable plastic cards may be used to illustrate interior waveforms where the specified methods of interior marking or space limitations are impractical. The equipment shall be designed to provide for connections for such test equipment as may be required for its expeditious maintenance, calibration, and repair. All test points shall be readily accessible with adequate clearance and visibility when plug-in extension units are in position. Connection of normally used test equipment to any test point shall in no way affect system performance.

3.9.2.10 Vertical rack panels.- Handles shall be provided on the front surface of each rack panel to facilitate its removal from the cabinet, and to provide adequate protection against damage to front surface mounted components when the rack panel unit is placed on a bench, front surface down, for maintenance and repair. All surfaces of items on the front of panels shall be at ground potential, or shall be insulated adequately from ground and protected properly to prevent accidental contact if the potentials are other than ground potential.

3.9.3 Parts requirements

3.9.3.1 Transistor and other semiconductor devices.- Equipment design shall be such as to utilize solid state devices throughout the equipment electronic circuitry in accordance with FAA-G-2100/3.

3.9.3.2 Semiconductor terminal identification.- All discrete transistors mounted on printed circuit boards shall have a character "C", representing the collector, on the wiring side of the circuit board, in a location approximating the collector terminal. In the case of field-effect semiconductors, the character "D", representing drain, shall be used.

3.9.3.3 Integrated circuits.- Solid-state microelectronic integrated circuits may be used and shall be in accordance with FAA-G-2100/5.

3.9.3.4 Relays.- Relays shall be in accordance with FAA-G-2100/1 paragraph 1-3.16.8.

3.9.3.5 Terminal blocks and connectors.- Each card bin, vertical chassis, and cabinet shall be equipped with connectors or barrier type terminal blocks for the termination of inter-unit and inter-cabinet cabling. Terminal blocks shall be mounted vertically inside the rear door of cabinets. The terminals of all terminal blocks shall be covered with removable clear plastic strip barriers having round access holes in line with each terminal to permit the insertion of a screwdriver blade or test probe. Suitable clamps shall be provided for each cable group.

3.9.4 Controls.- All circuits shall be so designed that no damage will occur when the equipment is operated with the operating controls and maintenance adjustments set to any possible configuration of settings. No fuses shall blow with actuation of any operational controls. There shall be no noticeable lag between the actuation or adjustment of controls and the effect of the actuation or adjustment. All controls shall have calibration marking to permit setting to predetermined positions, except where it can be demonstrated to the satisfaction of the Government that such compliance is impracticable or unnecessary. Maintenance adjustment controls shall employ small knurled knobs. Where the special nature of a function makes a large knob or screwdriver slot desirable, the use of such controls shall be subject to specific Government approval. Motor driven switches and controls are prohibited.

3.9.4.1 Location of controls.- Frequently used controls on plug-in modules shall be accessible without removal of the module from its normal position. Controls on units using vertical panel construction shall be on the front surface of the panel of the unit with which the control is associated. Controls for horizontal chassis units shall be mounted in front panels or immediately behind front access panel doors of each unit. All controls shall be mounted so as to minimize the possibility of personnel coming in contact with high voltages or components operating at high temperatures.

3.9.5 Radiation interference and susceptibility.- The design and construction of circuits, shielding and filtering shall be such as to meet the radiated and conducted emanations and the susceptibility requirements of Military Standard MIL-STD-461 for Class IC equipment. The susceptibility requirements of MIL-STD-461, Class IC, shall be met under the following conditions:

(a) At and above 200 MHz with all equipment installed in position, with cabinet door(s) open, and with one or more units or modules extended for off-line maintenance.

(b) Below 200 MHz with all equipment in their normal operation position with the cabinet door(s) closed.

3.9.6 System Grounding.- A common system grounding design criterion shall be used for all units to be delivered under this specification. The grounding design must be compatible with other equipment with which this system may interface. Line filters, if used, shall not introduce currents in the grounding system. The grounding design shall contain three discrete ground busses:

(a) One that bonds together all cabinets and frames.

(b) One that connects all signal return wires together.

(c) One that connects all power grounds together.

The cabinet/frames (a) and the signal return (b) ground busses shall be isolated from the power ground (c) and also isolated from building (earth) ground except that both busses (a) and (b) are to be connected to the building ground at one common connection point. Signal return paths for signals is that pass between units shall use the shield of the coaxial cable, or a separate signal return wire shall be provided for each path if coaxial cable is not required. The power grounding system (c) shall be separate from the other two busses. All internal equipment ground wires shall be at least 500 circular mills per linear foot. The portions of ground busses (a) and (c) external to equipment cabinets shall be at least #6 AWG stranded copper.

3.9.7 Finish.- Preparation for finish of all surfaces shall be in accordance with FAA-G-2100 (paragraph 1-3.8).

3.10 Special tools for maintenance.- All special tools necessary for repair, adjustment, or maintenance, not readily available on the open market, shall be supplied with each common equipment system.

3.11 Instruction books.- Instruction books shall be in accordance with FAA-D-638, and shall be furnished in the quantity specified in the contract schedule.

3.12 Trouble-shooting manuals.- Trouble-shooting manuals shall be in accordance with FAA-D-638, and shall be furnished in the quantity specified in the contract schedule. This book shall contain all diagrams and illustrations necessary for the isolation and repair of troubles within the system. It shall be designed for convenient use by maintenance technicians and shall not contain detailed descriptive information. It shall contain copies of the schematic diagrams and system cabling diagrams which are incorporated in the instruction book. In addition, it shall contain simplified, enlarged diagrams of functions designed to aid in the rapid isolation and correction of troubles within the system. Such simplified diagrams shall show separately, in skeleton form, the complete circuitry of such functions as video, trigger, etc., showing all test points in each circuit with the proper waveform for each test point. Separate wiring diagrams, in skeleton form, shall show and identify each plug, pin, terminal strip, meter, test point, switch, relay, etc., for the following circuits: ac power distribution, filament supply distribution, dc voltage supply distribution, metering, control functions and other circuits decided upon by mutual agreement between the Government and the contractor. All diagrams shall be arranged to permit simple, straight-forward tracing with functions and directions of travel clearly indicated.

3.12.1 Construction and binding.- The trouble-shooting manual shall be designed so that the book can be opened to any desired page and folded back upon itself so as to lay flat for easy reference during maintenance use. A multi-ring binding shall be utilized and shall be subject to the approval of the Government. Covers shall be stiff and durable and shall be made of cloth-covered cardboard or of laminated plastic to permit the book to be folded in a vertical position so as to be self-supporting with the selected page(s) nearly vertical. All diagrams shall be flat and not folded (except the system cabling diagrams). All diagrams shall be extra heavy and serviceable. The scale of schematic and system cabling diagrams shall be at least as great as that used in the instruction books. Disgrams shall be printed on only one side of the sheets.

3.12.2 Review and acceptance.- The procedures for instruction book review and acceptance specified in FAA-D-638 shall apply to the trouble-shooting manuals.

4. QUALITY ASSURANCE PROVISIONS

4.1 General.- The quality assurance provisions specified in FAA-G-2100/1 and FAA-STD-013 form a part of this specification and shall be complied with. Except where otherwise specified, all tests shall be performed at the design center values of line voltage and frequency. The contractor shall furnish all facilities and services necessary to complete all inspection and testing specified herein.

4.2 System tests.- Tests to show compliance with the requirements of this specification shall include but not be limited to those listed below. Production tests are marked (*), and shall be conducted under normal test conditions. Type tests to be performed under the environmental conditions of temperature and humidity in accordance with 1-4.3.3.2, FAA-G-2100/1, are marked (%). Design qualification tests marked (#) shall be conducted at line voltages over the complete range of service conditions (1-3.2.23, FAA-G-2100/1). Tests not marked (#) shall be at design-center voltages.

4.2.1 Specific tests.- The following tests shall be performed, as a minimum, on systems furnished under the contract. Conditions under which each test is to be performed are determined by the symbol(s) accompanying the test (*, %, #), whose meanings are defined in 4.2. Additional tests shall be required at any time during the contract run when deemed necessary by the Government to demonstrate performance in accordance with specification requirements.

Test	Specification Paragraph
Common Equipment	
(a) Range mark generator	3.4.3
*, % Range mark accuracy	
* Range mark circularity	
(b) Power supplies	3.5
*, %, # Regulation	
* Ripple	
*, # Output voltage	
* Isolation	
(c) Video line compensator/amplifier	3.4.2
*, % Video bandpass	
* Compensation	
*, % Output pulse characteristics	
* Trigger separation	
*, % Trigger jitter	
(d) * Control panel (operation)	
(e) * Relay panel (operation)	

5. PREPARATION FOR DELIVERY

5.1 General Packing Requirements.- Packing for shipment shall be in accordance with MIL-E-17555, except as otherwise specified in the contract schedule.

6. NOTES

6.1 Note on information items.- The contents of this Section 6 are only for the information of the initiator of the procurement request and are not a part of the requirements of this specification. They are not contract requirements nor binding on either the Government or the contractor. In order for these terms to become a part of the resulting contract, they must be specifically incorporated in the schedule of the contract. Any reliance placed by the contractor on the information in these subparagraphs is wholly at the contractor's own risk.

6.2 Options

6.2.1 Reliability demonstration option.- The contract will state specifically whether the Reliability Demonstration (3.8) is to be conducted.

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